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Original Articles, Selections and Translations.

ART. I.—PATHOLOGY OF THE VASO-MOTOR NERVOUS SYSTEM.

LECTURE II.

Vaso-Motor Centres in the Spinal Cord and Brain.—Reflex Vaso-Motor Action.—Relation of Vaso-Motor Centres in the Cord to Sympathetic.—Action on the Vessels Indirect.—Vascular *Tonus;* its Nature and Source.—Inhibitory Nervous Action; its Nature; Examples Nervous Apparatus of Heart and Vessels.—Theory of Action of Vaso-Motor Nervous System on Vessels.—Theory of Vaso-Dilator Nerves.—Functions of Muscular Vessels, etc.

GENTLEMEN: In my former lecture I was chiefly engaged in laying before you a few general facts in regard to the anatomy and physiology of the vaso-motor nervous system. I terminated what I then had to say by referring briefly to vaso-motor centres in the cord and brain. I will begin this lecture by an account of these centres.

Perhaps the first experimental observations of importance made in relation to them, were those of Budge and Waller. In their researches on the spinal cord of living animals, they found that sections, more particularly of its lower cervical and upper dorsal portions, led to the same phenomena, so far as the pupil of the eye is concerned, as when the cervical sympathetic is divided. This region of the spinal cord they named the *cilio-spinal.* The conclusion drawn from this experiment was, that the portion of the sympathetic which controls the movements of the iris, has its origin in the lower cervical region of the spinal cord.

Subsequently, M. Claude Bernard observed that the vessels of the head were innervated through the cervical sympathetic, from that portion of the spinal cord which is situated between the sixth cervical and fourth dorsal vertebræ. He admitted, in fact, two centres in this region, a cilio-spinal, and, below it, a vaso-motor centre.

Brown-Sequard, in the course of his experiments, ascertained that sections of the spinal cord, much lower down, had an influence on the unstriped muscular fibre of the head.

Subsequently, Budge and Schiff discovered another centre, the *genito-spinal*, extending from about the sixth dorsal vertebra down to the lower end of the cord, near which another centre, the *ano-spinal*, has been fixed, by M. Masius, of Liege. But, without entering into details, I may say that there is reason to think that there are vaso-motor centres scattered all along the substance of the cord, for different parts of the trunk: perhaps a continuous column of such centres, as M. Luys has supposed.

For my own part, I am strongly inclined to this opinion. But it is with this as it is with all mere opinions that I hold, I am ready to modify, or even abandon it, any day, if good reasons should appear for doing so.

Have vaso-motor centres been found in the cerebro-spinal axis, above the cilio-spinal? Yes. According to the researches of Schiff, Salskowsky, and Ludwig, and Thiry, the vaso-motor centre for the whole body lies in the medulla oblongata. Another investigator, Tscheschichin by name, has fixed it at the point of junction of the medulla oblongata, and pons varolii. Brown-Sequard would extend the vaso-motor tract up to the cerebellum and brain proper. But quite recently, Kronecker, at Leipsic, seems to have pretty definitely fixed the seat of a general vaso-motor centre for the whole body in the floor of the fourth ventricle.[*] That this is the true seat of a general vaso-motor centre seems probable, for it would then be near that wonderful constellation of special sensory and motor centres which lie in the medulla oblongata, pons varolii, and in the base of the brain. When we consider how suddenly a visual or auditory impression, carried back to the region in question, may be flashed out by reflex action to the whole voluntary muscular apparatus, or out on the vaso-motor system of nerves, giving rise to the almost instantaneous paleness and coldness of the cutaneous surface which we see in fear, or, on the contrary, the redness and heat of the surface which we see in shame, or under sudden and exciting passion, we seem obliged, in explaining such phenomena, to admit the existence of such a centre at the base of the brain; or, if you please, where Kronecker has fixed it, in the floor of the fourth ventricle, from which the whole vascular system may be controlled, and its action co-ordinated, or harmonized. But I must guard you against supposing that the actions of the whole vascular system are ordinarily controlled from this centre, any more than I would have you understand that all the movements we see in the limbs are excited from the corpus striatum. My belief is, that there are, at least in the lower animals, special vaso-motor centres in the whole length of the cord; but that these may, all of them, be excited from the general vaso-motor centre at the base of the brain.

Are these facts, obtained by experimentation on animals, also true for man? I believe they are. One reason for thinking so is, that the higher animals, and man, have been found to agree in so many other respects, in the physiological phenomena they present, as to lend a strong presumption in favor of essential identity in such a case as this. But there are other reasons. Of course, we cannot experiment on man as we do on animals; but it sometimes happens pathological cases furnish us proofs as much to the point as if they had been the result of direct experiment. Rendu,[†] among other cases, has reported several bearing on this point. In one case there was a luxation of the sixth cervical vertebra, and compression, to say the least, of the spinal cord in that region. Both pupils were extremely small; the face and neck were congested, and of a bluish red; and the color of the ears was that of an intense red; while other parts of the body below the head were unchanged in color. In this case, the condition of the cord was much the same as if it had been divided in the lower cervical region, as it has been in animals; and the effects are such as we would be led to expect beforehand. I could cite other observations, but, for my present purpose, one is as good as many. Besides such evidence as the case I have just mentioned, for the existence of vaso-motor centres in the cord and brain of man, as in the lower animals, there is another kind already referred to: it comes under the head of reflex action. Sensorial impressions are conveyed to the spinal cord and brain, along the course of cerebro-spinal nerves, such as the auditory or optic nerves, or the cutaneous nerves, as those of tact, or those which take cognizance of changes in temperature; and they are often reflected outward, not along cerebro-spinal, but vaso-motor nerves: sometimes so as to affect suddenly the action of the whole vascular system. Such phenomena, and they are very common, show there are vaso-motor centres in the cerebro-spinal axis.

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[*] *Vulpian: Experiences pour rechercher si tous les Nerfs Vasculaires ont leur foyer d' Origine, leur Centre, Vaso-Motor, dans le Bulbe Rachidien.—Rev. Scientifique*, 1874, No. 35, p. 834.

[†] *Des troubles fonctionnels des grand sympathetique, observes dans les plaies de la moelle epiniere.—Arch. gen de Med.*, 1869; p. 286–297.

Let it then be regarded, as provisionally established, at least, that there is a line of vaso-motor nervous centres, in the spinal cord, extending its whole length up to the brain. This, if true, is an important fact. It will show us how it is possible for sensorial impressions—whether healthy or morbid when conveyed into the spinal cord—to be reflected out from closely related vaso-motor centres in the cord, so as to produce vaso-motor disorder in corresponding parts of the body. One of the best examples of this kind of action I can cite you to is congestion of the respiratory mucous membrane, following an exposure to cold. In this instance, an impression is made by the cold air, we will suppose, on the periphery of a cerebro-spinal nerve; the impression is conveyed to the spinal cord or medulla oblongata, and is reflected out from a vaso-motor centre, along vaso-motor nerves, to the vessels of the mucous membrane of the nose, or larynx, or trachea, and a congestion results, certain consequences follow, and we say the person has taken a "cold."

But the vaso-motor disturbance may be in many other parts of the body as well as the respiratory mucous membrane. It may be in the uterus, or mucous membrane of the bladder, or bowels; or it may be the lungs, or liver, or kidneys, or other parts, as a muscle, for example; but in either case, a vaso-motor disturbance arises in the organ, that may lead, according to its location, to a pneumonia, or a colitis, or hepatitis, or to uterine or vaginal, or vesical congestion, or inflammation; and the sensorial impression which leads in the way I have supposed, to reflex vaso-motor disorder, need not be made on the cutaneous surface. It may be made on any of the mucous surfaces, or in any of the solid organs of the body, and lead, finally, to vaso-motor disorder, even in remote parts. Moreover, the impression which leads to the vaso-motor disorder may arise in the brain, or even in the spinal cord itself, as a result of mental, or, more likely, various *emotional* states, which affect the brain in certain ways, which, in turn, sends an influence down to the vaso-motor centres in the spinal cord, that may produce essentially the same effects, as, for example, the peripheral impression of cold. These injuries and diseases of the spinal cord may, and do, become, the causes of a disturbance in the action of vaso-motor centres that may be involved in the disease; and thus, in all these ways, give rise to vascular disturbances in various parts of the body. But I have said enough to show you that the discovery and fixation of vaso-motor centres in the cerebro-spinal axis is a matter of no small importance in pathology. I will, hereafter, have frequent occasion to apply the principles I have been seeking to establish.

Hoping you will bear in mind clearly what has been just said, I wish to inquire briefly by what routes vaso-motor fibres which arise in the vaso-motor centres of the cord and brain, escape from the spinal cord. They do so in two ways: by the *rami communicantes*, which pass between the spinal nerves and the sympathetic ganglia, and also by the spinal nerves themselves, especially those which pass out to the extremities.

Another question of importance is, whether the outgoing fibres in question extend outward, until they are finally distributed to the vessels? Do these fibres, which arise in the spinal cord, act *directly*, or *indirectly*, on the muscular vessels of the body?

This is a question of no small importance, as I hope soon to show you. For my own part, I have but little hesitation in saying, their action is indirect. If it were direct, it would be necessary, in many instances, for the vaso-motor fibres which arise in the cord to extend from the points of their origin to remote parts of the body. But there is not the slightest proof of this; neither is it proved, positively, that they do not continue uninterruptedly between the spinal cord and the vessels. We have to rely on indirect evidence in this case. But it all seems to me, to speak in favor of the view, that the spinal vaso-motor centres do not act directly on the muscular vessels. What the indirect proof is to which I refer, I will presently show you.

But, suppose the action in question to be indirect, can we so state the process or mode of it as to explain the facts of the case? Let us see. If the vaso-motor centres in the cord and brain do not act directly on the vessels, it must be by means of an intermediate nervous apparatus. In this view, the vaso-motor fibres, which take their origin in the cerebro-spinal axis, pass outward, and terminate at their peripheral ends—not in the muscular coat of the vessels, but in the ganglia of the sympathetic—and it may be isolated ganglion cells of the same that I have already mentioned as thickly strewn in different parts of the body. According to this view, the vaso-motor fibres originating in the cord and brain, excite to increased action, or, on the other hand, depress the action of the subordinate ganglia of the sympathetic.

If from the vaso-motor centres in the spinal cord, the sympathetic ganglia are excited to increased action, the muscular vessels—the action of which these ganglia directly control in their turn—contract, as they do when the nerves leading to them are excited by the galvanic current. If the sympathetic ganglia are depressed or arrested in their action by the spinal centres, the vessels relax in the same way as when the nerves leading to them are paralyzed.

Before proceeding farther, I must explain what is meant by *vascular tonus.* By this is meant an enduring state of contraction of the muscular walls of the blood-vessels, by means of which they embrace, with a varying degree of force, the column of blood they normally contain. How is this state of vascular tension maintained? What affords such a constant stimulus to the muscular tissue of the vessel? This stimulus comes, I have no doubt, from the vaso-motor nervous system. But what excites this nervous system so that it emits such a steady tide of motor influence to the muscular wall of the vessels? Is the action in question direct, or reflex? It may be either; but in my opinion it is, as a rule, reflex, as is the case with the heart, which is usually excited to action by the blood which fills it—so with the small muscular vessels.

They are, in health, unlike the heart, constantly filled with blood. There is the continuous impression of the blood, not only on the lining membrane of the vessel, but, possibly by constant expansive pressure, the muscular fibres are provoked to as constant contraction. From one or both these sources an enduring sensory or centripetal impression is sent back to the related vaso-motor centre or centres; and this leads to a reflex motor impulse, which is conveyed by motor nerve fibres to the muscular coat of the vessels, which, of course, contracts. Inasmuch as the sensorial impression is continuous, so is the resulting reflex contraction; and this is what is called *vascular tonus.*

The state of the vessels I have described may not be wholly due to special tonic centres, but may depend on any vaso-motor centre, whether in the cord or out of it, though, ordinarily, there can be little doubt it depends much on the larger or more central ganglia, which command wide vascular areas.

But what proof have we that the action of the spinal vaso-motor centres on the vessels is indirect? I will now call your attention, at some little length, to what has been called "inhibitory" nervous action, and in so doing answer my question. I can cite but few examples of this kind of action; my intention is, rather, to explain it to you. It is very common, especially in the cerebro-spinal nervous system.

The tendency in the spinal cord and medulla oblongata, is naturally to reflex or independent action. Coughing, sneezing, winking, breathing, and involuntary movements of the limbs, when the skin covering them is irritated, are examples of such movements. But, in spite of this natural tendency to reflex action, carried on through the special motor centres of the cord and medulla, we can, and in health, ordinarily we do, control, or even entirely arrest, such action, by an effort of the will.

The will acts from the cerebral centres, above in the brain, which centres send down commands that arrest or inhibit certain actions that otherwise would inevitably occur. A higher centre excites or arrests, at pleasure, as it were, the action of a lower centre, while the state is a normal one. This is *inhibitory nervous action.*

It is easy to give examples of it. At this point I would be glad to speak of various interesting experiments which have been made, and facts which have been collected, by such writers as Setschenow, Bezold, Pflueger, Hermann, Goltz, Schiff, Brown-Sequard, Handfield Jones, and others; but I have no time for this now.

There is one example of inhibitory nervous action, however, so complete, and so much to my purpose, I will describe it with some detail. I now refer to the action of the nervous mechanism of the heart. I will describe, first, the nervous apparatus of the heart, briefly; and this is all the more important, because the heart, like the small muscular vessels, the action of which it is one of our chief purposes to consider in these lectures, forms a segment of the vascular circle.

The heart forms a singular compromise, in respect to its structure and nervous mechanism. In its *structure*, it is allied to the voluntary; in its *action*, to the involuntary, muscles. On the one side, it is dependent on the sympathetic, and, on the other, it depends on the cerebro-spinal nervous system.

The nervous apparatus of the heart, has been investigated by many physiologists, but by none more thoroughly or successfully than by Bezold, of Jena, and the Cyon brothers, of St. Petersburgh.

The result of investigation is to the effect that the heart has, in its own structure, a special nervous system, consisting, of course, of ganglia and nerve fibres. These cardiac ganglia have been divided into two classes, *motor* and *regulator*. The motor ganglia of the heart give off, as well as receive, nerve fibres, the former being distributed to the muscular tissue of the heart. The fibres from the regulator ganglia do not go to the muscular tissue of the heart, but to the motor ganglia. They may restrain, or altogether stop, the action of the motor ganglia, and, by consequence, the action of the heart. The action of the regulator ganglia is, therefore, of the kind I am trying to describe to you, *inhibitory*, as well as exciting.

But this is not all that is to be said in regard to the nervous mechanism of the heart. The heart is supplied, *ab extra*, not only by sensory but motor nerves. The latter are from two sources, the cerebro-spinal and the sympathetic nervous sys-s. The one, the vagus or pneumogastric, is an inhibitory rve, the motor nerves from the sympathetic being the so-alled "accelerator" nerves discovered by the Cyon brothers. The vagus does not terminate in the muscular tissue of the heart, but in the regulator ganglia. By influencing these, the action of the heart can be depressed, or even completely arrested. On the contrary, the "accelerator" nerves, terminating, it may be, both in the regulator and motor ganglia, if irritated, lead to accelerated cardiac action.

This is an excellent instance of inhibitory action. We see certain ganglia controlling the action of others. In my opinion, this is the way the larger ganglia of the sympathetic, but more particularly the vaso-motor centres in the spinal cord, act on the smaller sympathetic ganglia and ganglion cells that are so thickly disseminated through the body, and which, in their turn, act directly on the vessels. The one class of these ganglia bears the same relation to the other as the regulator do to the motor ganglia in the heart.

But as this is an important point, I must be explicit. My opinion, more fully stated, as to the action of the vaso-motor nerves on the vessels, is this: Each muscular vessel, or small vascular territory, has its ganglion, or group of ganglion cells, on which it is directly dependent. This nervous apparatus is quite sufficient for ordinary purposes. But it needs control, and, in view of thousands of similar mechanisms, co-ordination, so as to maintain an equilibrium of action in the whole body. This must be done by ganglia that have a wider sweep of relations; and as you retreat from the remoter parts of the body towards the centre, we find such ganglia larger in mass, and more extensive in connections—representative ganglia. Such ganglia we find in the chain of these bodies, on either side of the spinal column, and in the semilunar ganglia of the solar plexus. For the mere purposes of vegetative life, this is sufficient. For the sympathetic nervous system, especially its peripheral portion, is developed before the cord and brain, as is seen more particularly in the case of those monsters which at birth have no brains, or even no perfect spinal cord, yet the vaso-motor system of nerves is well developed in its peripheral portions, and the vegetative processes go on.

But in the case of vertebrate animals, there is no commanding centre, outside of the brain and cord, from whence the whole vaso-motor nervous system may be acted on at once, and in this way equilibrium in action secured, as between widely separated vascular areas. Then again, the vaso-motor nervous system must be placed in close relation with the central nervous system, so that there may be close intercommunication between what is purely physiological and what is purely mental in the lives of animals, but especially man. Accordingly, we have a chain of vaso-motor centres in the cord extending up toward the brain, the whole system culminating in a supreme centre, in the floor of the fourth ventricle, perhaps, towards which all lines of centripetal vaso-motor impulse tend, and from which all general centrifugal impressions, destined to affect the action of the whole vaso-motor system, must proceed. This chief centre forms a worthy member of that wonderful society or constellation of special centres massed at the base of the brain, within easy reach of each other.

In this view, the centre for ordinary action of a vessel, would be the nearest ganglion or ganglion cell. Nerve fibres, sensory and motor, pass between the ganglion and vessel. If all other nerve centres were cut off from this, it might still act independently; but in the observed order of things, all these ganglia are arranged with reference to associated action, so if one ganglion suffers or is destroyed, there is, at least, temporary disorder produced in the action of related ganglia. This may be called the *proximate* or *primary*, or *direct motor* class of ganglia. They are peripheral, exceedingly numerous, and very small, and are always situated very near, or even *in* the structure of the organs they are expected to influence.

If we retreat toward the centre of the body, we encounter a second class of ganglia, fewer in number, more massive, and better isolated, than those of the first class. They may be compared to the *regulator* ganglia of the heart. They may constitute the *secondary* or *regulator* class, if you please. I would not have you understand, however, that they might not perform the office of the first class, also, in regard to vascular areas in their neighborhood.

As examples of this class, I would point to all the larger, more central, sympathetic ganglia. If they should be destroyed, and they often are, still, the ganglia of the first class, if they maintain their integrity, are able, after a fashion, to act alone. As already intimated, though the ganglia of the second class are associated by intervening cords, yet no one of them can be considered as representative or chief in rank. They need, in their turn, controlling and co-ordinating centres; hence, we have a tertiary class, fewer in number, more central, and less independent of each other, than is true of either of the other classes, and these are found in the cerebro-spinal axis; and the nerve fibres which proceed from these spinal centres may be compared to the *vagus*, which acts on the regulator ganglia in the heart, which regulator ganglia of the heart belong to the second class of vaso-motor ganglia that I have described.

Finally, at the cephalic end of the chain of this third class of vaso-motor centres, and in perfect analogy with the mode of arrangement and action in the cerebro-spinal nervous system, we find a supreme vaso-motor centre, from which the whole system of vaso-motor nerves *may* be controlled, if the exigency requiring it should arise.

If what I have been saying to you is true, there is a close analogy as regards the nervous mechanisms which control the two muscular segments, the cardiac and the arterial, in the great vascular circle of the body. I see no reason to doubt the truth of the analogy I have traced. Before I pass on, I ought to tell you the analogy I have mentioned may not hold good altogether. I think the nervous apparatus of the vessels may be less complex than that of the heart. For example, it may not be necessary to admit, for the vaso-motor mechanism of the vessels, a system of nerves similar to the *accelerators* of the heart. It may suffice to admit, as going from the spinal centres, one set of nerves, to be compared to the vagus in its action on the regulator ganglia of the heart.

But I am simply giving you my opinion in many of these matters; and you know opinions often have to be altered, or even abandoned. On the other hand, it may be true we have two kinds of nerves proceeding from the spinal vaso-motor centres, one of which, by exciting the ganglia of the second class to action, would, in turn, through those of the first or proximate class, excite the vessels to increased action or vascular tonus, that is, to more energetic contraction, and so in this way diminish their calibre; or, by depressing the action of the regulator ganglia lead, through the same channel as before, to a diminution of vascular tonus, and so permitting a vessel to relax and expand. In this latter way, congestions of blood may be explained, as we may see in the next lecture.

Such is the probable way in which, it seems to me, the vaso-motor system acts on the muscular vessels. But there is another way of explaining vaso-motor phenomena, which differs from the one I have given you in some particulars. It has had some eminent physiologists as its supporters in times past, such as Schiff and Bernard. But few are inclined to accept it now; and of its two former supporters I have just mentioned, Bernard certainly appears to have abandoned it for another view, which seems to me scarcely more tenable than the one for which it was exchanged. It differs from the above mode of explanation in that it admits two kinds of vaso-motor fibres, which *act directly on the vessels.* I am inclined to admit two kinds of fibres which act on the regulator ganglia, but *not directly on the vessels.* Of these two classes of fibres which are said to act directly on the vessels, the first are called *vasor-constrictors.* If they are irritated, they lead to contractions of the muscular walls of the vessels. We may admit this kind of action, for up to this point the two modes of explanation can agree. The other class, when irritated, lead, as is supposed, singularly enough, to *dilatation* of the vessels, which is in this view just as *active* a process as the contraction is by all admitted to be. In the view I am inclined to adopt, the dilatation of the vessel is not an active process, so far as the wall of the vessel is concerned, but a *passive* one. The point at which *action* terminates is not in the *vessel*, but in the *motor ganglia* of the first or proximate class, on which the vessel is directly dependent. I see no more reason for admitting a *dilator* nerve in this case than I do for admitting a *relaxing* nerve for a voluntary muscle, when it relaxes upon the withdrawal of its nervous stimulus. Certainly, no one would think of a relaxing nerve leading to the muscle, for the voluntary muscles. The point of *positive* action in the latter case is at the spinal cord; of *negative* action, at the muscle. And so I believe it is for the involuntary muscle of the vessel. But, having admitted vaso-dilator nerves, the mechanics of active dilatation require explanation; but that is not possible without supposing a peculiar disposition of muscular fibres in the walls of the vessels, which supposition not only lacks the confirmation of actual observation, but even of analogy.

The phenomena which at first induced Schiff, Bernard, and others, to adopt this view, are very interesting, and I cannot pass them without mention and comment. They refer to certain vascular and related secretory phenomena observed during experiments on the submaxillary gland and its nerves. It has been found, in regard to the circulation in this gland, that if the sympathetic nerve fibres leading to it are destroyed, there is the usual enlargement of the blood-vessels, or congestion, that is always observed when the sympathetic leading to the vessels of a part are divided so as to separate them from their controlling centres. But there is no increase in the salivary secretions corresponding to the increased supply of blood. But now, if, in the case of another animal, the sympathetic remaining intact, the *chorda tympani* nerve is irritated, say by means of the galvanic current, the blood-vessels immediately dilate, but with more appearance of activity than was observed in the dilatation which took place after the sympathetic was divided. Moreover, the secretion from the salivary duct is vastly increased, which was not true after division of the sympathetic. There are other phenomena accompanying those already mentioned worthy of notice; but I pass them by now. What we wish to have explained is, the dilatation which follows irritation of the chorda tympani nerve. It is in the attempt to explain such cases as I have just described, that certain physiologists have been led to admit the existence of *vaso-dilator* nerves. The chorda tympani was said to be a nerve of this class. The irritation of no other nerve leading to the submaxillary gland led to any such phenomena, but the contrary. How shall we explain the phenomena I have described? They certainly are curious. There are two ways, so far as I know, that have been proposed: one is, to admit dilator nerves; the other is, to suppose, as Bernard has more lately done (if I understand him correctly), that by irritating the *chorda tympani* nerve, you do not act directly on the vessels, but on the secretory structure and nutrition of the gland, creating, in this way, a demand for more blood, which, by a species of attraction supposed to exist between the tissues and blood, creates a tide or flux of blood in the direction of the gland, and in this way leads to vascular dilatation. Of this latter purely hypothetical mode of explaining the phenomena in question, I cannot now speak. I will do so hereafter, fully, when speaking of congestion. But of the two hypotheses, I must confess, if I had to choose one or the other, I would adopt the first; and I do not think it tenable. But you will ask me, perhaps, if I reject the above explanations of the phenomena as untrue, how I would explain them myself? I would answer, that I do not know of any certain way of explaining them. Besides, the rejection of one hypothesis does not have coupled with it the necessity of substituting another in its stead. But what seems to me a better way of explaining the phenomena in question, is this: When the chorda tympani is irritated, it does not act on the vessels of the gland at all, but on the secretory structure, exciting it to increased activity. This increased activity requires, as its correlate, more blood. Now, how is it obtained? I take it to be as follows:

The excitement of this secretory structure, by irritation of the chorda tympani, gives rise to a sensorial impression in the gland, which is carried along certain nerves to the appropriate vaso-motor centres of the glands, and so influences them as to diminish the vascular tonus of the vessels they supply, at the same time, and in the degree required, by the excitement of the secreting structure by the secretory nerves, if you please. This view violates, so far as I know, no principle in the physiology of the nervous system. It requires, it is true, a hypothetical connection between the supposed secretory and vascular nerves. But the supposition violates no analogy, but, on the contrary, is supported by many.

It makes it necessary to have certain nerves whose office it is to excite to action the secreting structure of glands. This is no unfamiliar conception in physiology. In the next place, it makes the excitation of the glandular tissue give rise to a sensorial impression, at the periphery of nerve fibres, which lead, we will suppose, to a regulator vaso-motor centre, which, in turn, by a reflex act, *inhibits* or arrests the action, or capacity for action, of the direct vaso-motor centres for the vessels of the gland, and, as a result, the vascular tonus of the same is diminished, and the vessels relax so as to admit a greater volume of blood to the gland, as one of the essential conditions of an increased secretion. The difference between this case and the one in which the sympathetic was divided, and more blood, by consequence, was admitted to the gland, consists in this: that in the one case the secretory nerves, viz.: the chorda tympani, is excited, while in the other it is not. The explanation I have offered you, if it is worthy of the name, would make the dilatation of the vessels, following irritation of the chorda tympani, a reflex result, which, as such, has its origin and measure in a sensorial impression arising in the secreting structure of the gland, in consequence of its excitation by the "excito-secretory" nerve of the gland, viz.: the *chorda tympani*. But I need not dwell longer on this case, important as it is. In my judgment, it may be so explained as to make it conform to the theory of vaso-motor nervous action I have adopted, and tried in a plain way to set before you. I would not have spent so much time with this matter as I have done, but it is one of very great importance in the pathology of the nervous system. I have been willing to be a little prolix, even tedious, to place before you what most assuredly you will not find stated with the same fullness, nor exactly in the same way, in any books accessible to you.

I would not have you suppose the views I have advanced are essentially new. The facts I have referred to are well known. If there is anything new in what I have said to you, it consists in the mode of interpretation of the facts. It now remains to me to bring the hypothesis I have set before you, face to face with the observed phenomena in health and disease, as regards the action of the small vessels. This will require me to review the whole subject of vascular action, congestion and inflammation. The questions we are now to open are among the most central and living in the whole field of pathology.

Before I enter on their consideration, however, I must say a few words to you in regard to the physiological office of the small muscular vessels.

There is one office they have, about which all observers are agreed; it is this: by their contraction or dilatation they regulate the quantity of blood that may be admitted to the capillaries of a part. This office is an important one, and cannot be too much dwelt on in its relations to the nervous system.

But I will pass it by now, to speak of another supposed function of the muscular vessels. It is one I have myself, for twelve years or more, maintained as probable.* It is that of their propulsive action, aiding in circulating the blood through the capillaries by a sort of vermicular contraction, varying in its degree. But the discussion of this important subject must be left until my next lecture.

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* See the *Chicago Medical Examiner* for 1864, and the Transactions of the Ill. State Med. Soc. for 1863.